03-29-06 Kinetic Theory of Gases — Chpt 10 Test starts here!

- 3 types of motion
  1) Translational motion (a molecule from A → B)
  2) Rotational motion
  3) Vibrational motion

→ liquid & gases can do all 3 } natural E of the particle.
→ solids can only vibrate.

Kinetic Molecular Theory: ~~any gas~~ assume all gases are ideal gases.

- ideal gas - any gas that conforms to the kinetic molecular theory.

[Main]
5 Points to Kinetic Molecular Theory

1) All gases consist of large #s of tiny particles
*ideal situation 2) All particles are in a constant state of motion.
3) All collisions between gas molecules are elastic collisions (=) no KE is lost)
4) Assume there is NO forces of attraction between molecules.
5) KE of a gas particle (=) its speed) is directly proportionate to Kelvin Temp.
   → as temp ↑ =) KE ↑.

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- STP =) Standard temperature & Pressure
  (0° C [273° K], 1 atm [760 torr, or 760 mm Hg])

5 Major Properties of Gases

1) Gases are expandable
2) Gases are compressible
3) Diffusion --) gases can mix in the absence of air currents.
4) Fluidity --) gases molecules can glide past one another without attraction.
   ↳ AKA pourable
5) Gases have a very low densities. - measured in $\frac{g}{L}$

- Real Gas - any gas that deviates from Kinetic molecular theory.

→ most commonly caused by an attraction between gases.
   ex H_2O ↑ [needs to be polar] --) electronegativity difference.
   --) dipole interaction.
   - under high pressure & low temp =) causes this.

Qualitative Description of Gases --) 4 variables

1) moles (n) → # of particles
2) temperature (T) [avg. KE] --) MUST BE IN KELVIN! K = C + 273.
3) volume (V) --) space occupied
4) pressure = $\frac{\text{force}}{\text{area}}$ = $\frac{\text{\# of collisions a gas makes}}{\text{wall of container}}$

April 5, 2006 Chemistry Notes Block E

4 variables-

① moles (n)

② Temp (T)

③ Volume (V)

④ Pressure = $\frac{force}{area}$

- # of collisions
- in units of mm Hg, torr, atm, and kPa

Qualatative Description of Gas Behavior-

① V vs. P @ constant T + n

- V↓, P↑ why? b/c in a smaller space, more gas molecules collide, thus P↑. (inversely proportional)

② V vs. T @ constant P + n

- T↑, V↑ why? b/c particles are now moving faster, so gas will expand and occupy a larger V, in order to keep the same number of collisions. (directly proportional)

③ P vs. T @ constant V + n

- T↑, P↑ why? b/c particles moving faster b/c of ↑T = more collisions so P↑. (directly proportional)

④ n vs. V @ constant P + T

- n↑, V↑ why? b/c more gas occupies more space. (directly proportional)

⑤ n vs. P @ constant T + V

- n↑, P↑ why? b/c more gas in a confined V means more collisions so P↑. (directly proportional)

Pressure Measurements-

1643 - Torricelli used Hg Barometer which measured atmospheric pressure.

- Standard P = 760 mm Hg = 760 torr = 1 atm (atmosphere) = 101.3 kPa

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Standard Pressure = 760 mmHg = 760 torr = 1 atm = 101.3 KPa *

Quantitative Behaviors of Gases

- V vs. P [constant T & n] --> Boyle

$V \uparrow \times 2 \Rightarrow P \downarrow \times \frac{1}{2}$ [a true inverse relationship]

$V_1 P_1 = K$ } not a true constant --> b/c of relationship to temperature.
$V_2 P_2 = K$ } --> pressure is temperature dependent.

=> if V changes, P changes to give same constant.

- if K = K --> $\boxed{V_1 P_1 = V_2 P_2}$ --> Boyle's Law ***

EX.: If a 25.6 mL sample of N_2 has its pressure raised to 818 torr and occupies a new volume of 21.0 mL what was the original pressure in atm.?

V_1 = 25.6 mL
P_1 = X --> in atm.
V_2 = 21.0 mL
P_2 = 818 torr

$P_1 = \frac{V_2 P_2}{V_1}$

$= \frac{(21.0 \text{ mL})(818 \text{ torr})}{(25.6 \text{ mL})} = 671.02$ torr

* make sure units cancel!

- 1 atm = 760 torr

- $671.02 \text{ torr} \cdot \frac{1 \text{ atm}}{760 \text{ torr}} = \boxed{0.883 \text{ atm.}}$

- V vs. T (at a constant P & n) --> directly proportionate : V ↑, T ↑

--> Charles : if T ↑ by 1° (C° or K) => V ↑ by $\frac{1}{273}$

$T_1 = KV_1 \Rightarrow K = \frac{T_1}{V_1}$
$T_2 = KV_2 \Rightarrow K = \frac{T_2}{V_1}$

$\Rightarrow \frac{T_1}{V_1} = \frac{T_2}{V_2} \Rightarrow \boxed{V_1 T_2 = V_2 T_1}$ --> Charles' Law

*** temperature ALWAYS has to be in K
- b/c --> of the ratio of $\frac{1}{273}$
& b/c if C --> could get negative volume.

EX: A gas @ STP has a volume of 6.78 L. What is the new volume of the gas when temperature changes to 80.0 °C & P is constant.

V_1 = 6.78 L
V_2 = X
T_1 = 0.00 °C (b/c of STP) --> 273 K
T_2 = 80 (°C) --> 353 K
need to use Kelvin!!

$\Rightarrow V_2 = \frac{V_1 T_2}{T_1}$

$= \frac{(6.78 \text{ L})(353 \text{ K})}{(273 \text{ K})} = \boxed{8.76 \text{ L}}$

- K = 273 + C

MAKE SURE TEMPS ARE IN KELVIN! DON'T CONFUSE WHERE TEMPS GO!
"remember to rationalize answers as well"

04-07-06

Gay-Lussac --> worked on P & T at constant n & V.

→ If T ↑ 1° (C or K), P ↑ $\frac{1}{273}$ [same as vol. w/ Charles' law]

--> $T_1 = KP_1$ ⟹ $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ ⟹ $\boxed{P_1T_2 = P_2T_1}$

$T_2 = KP_2$

↳ Gay-Lussac's Law.

★★★ TEMPERATURE MUST BE IN KELVIN!

- Boyles Law: $V_1P_1 = V_2P_2$ [temp. const. & moles const.]

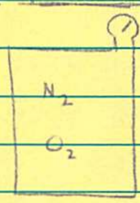
- Charles' Law: $V_1T_2 = V_2T_1$ [constant P & n]

- Gay-Lussac's Law: $P_1T_2 = P_2T_1$ [constant V & n]

Combined Gas Law: $\boxed{V_1P_1T_2 = V_2P_2T_1}$ ***

04-10-06

Partial Pressures



--> (764 torr) → total pressure

ex. atmospheric pressure (pressure of all gases combined)

- at high P & low temp → all gas particles behave the same [the Kinetic-Molecular Theory]

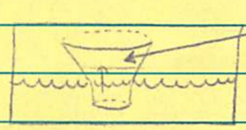
- $P_t = P_1 + P_2 + P_3 + \ldots$

Dalton's Law of Partial Pressures.

EX. P_{O_2} → 205 torr, P_t → 764 torr, P_{N_2} ?

⟹ $P_{N_2} = P_t - P_{O_2}$ = 764 torr − 205 torr = 559 torr

Water Vapor Pressure (WVP)



C_4H_{10} + H_2O ↑ } a wet gas → b/c has WVP

- dry gas → a gas where WVP has been subtracted out.

EX. What P of dry Butane when 23.0 mL are collected at 732 torr & 22.0°C

- P_t = 732 torr [wet gas] (P 899 → table of WVP)

- at 22.0°C → WVP = 20.4 torr.

⟹ $P_{C_4H_{10}}$ = 732 torr − 20.4 torr = 711.6 torr

EX (cont) → when 23.0 mL of C_4H_{10} via water displacement at 732 torr & 22.0°C, what is the vol. of the dry gas at STP?

[1st step above] → use the Combined Gas Law.

764 torr

3 mol N_2
2 mol O_2

- solve for partial pressure of N_2 (gas particles do not discriminate)

- total 5 mols total

- $\frac{3}{5}$ gas is N_2 ⟹ $\frac{3}{5}$ of pressure is from N_2 ⟹ $\frac{3 \text{ mol } N_2}{5 \text{ mol total}} \cdot 764$ torr = 458 torr